TURBOFAN ENGINE

BACKGROUND OF THE INVENTION

[0001] This invention relates to a turbofan engine, and more particularly, the invention relates to a turbofan engine having an effectively variable nozzle exit area.

[0002] A turbofan engine typically includes a fan nacelle surrounding a core nacelle. A spool is housed in the core nacelle and supports a compressor and turbine. A turbofan is arranged in the fan nacelle upstream from the core nacelle. Flow from the turbofan bypasses the core nacelle through a bypass flow path arranged between the core and fan nacelles. The bypass flow path includes an exit nozzle that is typically fixed. In many turbofan engines, the turbofan is driven directly by the spool and rotates at the same speed as the spool.

[0003] The engine's design is affected by such factors as the pressure ratio of the turbofan. Propulsive efficiency improvements, and hence fuel consumption, can be gained by reducing the turbofan pressure ratio. Direct drive turbofan engines have several design challenges. In one example, the speed of the spool is determined by the appropriate tip speed for a desired turbofan pressure ratio. In some applications, as the turbofan pressure ratio is reduced, additional compressor and turbine stages must be added to the spool to obtain the needed amount of work from the compressor and turbine at this speed. The result is increased engine weight and cost.

[0004] Some turbofan engines employ structure at the aft portion of the bypass flow path that is used to change the physical area of the nozzle. This arrangement enables manipulation of various engine operating conditions by increasing and decreasing the nozzle area. However, this type of engine arrangement has used a turbofan driven directly by the spool.

[0005] What is needed is a turbofan engine having a turbofan that is decoupled from the low spool and provisioned with an effectively adjustable fan nozzle that provides improved efficiency.

SUMMARY OF THE INVENTION

[0006] A turbofan engine is provided that includes a fan nacelle surrounding a core nacelle. The core nacelle houses a spool. The fan and core nacelles provide a bypass flow path having a nozzle exit area. A turbofan is arranged within the fan nacelle upstream from the core nacelle. A flow control device is adapted to effectively change the nozzle exit area to obtain a desired operating condition for the turbofan engine. A gear train couples the spool and turbofan for reducing a turbofan rotational speed relative to the spool rotational speed.

[0007] These and other features of the present invention can be best understood from the following specification and drawings, where the following is a brief description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. **1** is a cross-sectional view of an example turbofan engine.

[0009] FIG. **2** is a partially broken perspective view of the turbofan engine shown in FIG. **1**.

[0010] FIG. **3** is a schematic of a gear train shown in FIG. **1**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] A geared turbofan engine **10** is shown in FIG. **1**. A pylon **38** secures the engine **10** to an aircraft. The engine **10** includes a core nacelle **12** that houses a low spool **14** and high spool **24** rotatable about an axis A. The low spool **14** supports a low pressure compressor **16** and low pressure turbine **18**. In the example, the low spool **14** drives a turbofan **20** through a gear train **22**. The high spool **24** supports a high pressure compressor **26** and high pressure turbine **28**. A combustor **30** is arranged between the high pressure compressor **26** and high pressure turbine **28**. Compressed air from compressors **16**, **26** mixes with fuel from the combustor **30** and is expanded in turbines **18**, **28**.

[0012] Airflow enters a fan nacelle **34**, which surrounds the core nacelle **12** and turbofan **20**. The turbofan **20** directs air into the core nacelle **12**, which is used to drive the turbines **18**, **28**, as is known in the art. Turbine exhaust E exits the core nacelle **12** once it has been expanded in the turbines **18**, **28**, in a passage provided between the core nacelle and a tail cone **32**.

[0013] The core nacelle **12** is supported within the fan nacelle **34** by structure **36**, which are commonly referred to as upper and lower bifurcations. A generally annular bypass flow path **39** is arranged between the core and fan nacelles **12**, **34**. The example illustrated in FIG. **1** depicts a high bypass flow arrangement in which approximately eighty percent of the airflow entering the fan nacelle **34** bypasses the core nacelle **12**. The bypass flow B within the bypass flow path **39** exits the fan nacelle **34** through a nozzle exit area **40**.

[0014] For the engine **10** shown in FIG. **1**, a significant amount of thrust may be provided by the bypass flow B due to the high bypass ratio. Thrust is a function of density, velocity and area. One or more of these parameters can be manipulated to vary the amount and direction of thrust provided by the bypass flow B. In one example, the engine **10** includes a structure associated with the nozzle exit area **40** to change the physical area and geometry to manipulate the thrust provided by the bypass flow B. However, it should be understood that the nozzle exit area might be effectively altered by other than structural changes, for example, by altering the boundary layer, which changes the flow velocity. Furthermore, it should be understood that any device used to effectively change the nozzle exit area is not limited to physical locations near the exit of the fan nacelle **34**, but rather, includes altering the bypass flow B at any suitable location in the bypass flow path.

[0015] The engine **10** has a flow control device **41**, indicated in FIG. **2** that is used to effectively change the nozzle exit area. In one example, the flow control device **41** provides the fan nozzle exit area **40** for discharging axially the bypass flow B pressurized by the upstream turbofan **20** of the engine **10**. A significant amount of thrust is provided by the bypass flow B due to the high bypass ratio. The turbofan **20** of the engine **10** is designed for a particular flight condition, typically cruise at 0.8 Mach and 35,000 feet. The turbofan **20** is designed at a particular fixed stagger angle for an efficient cruise condition. The flow control device **41** is operated to vary the nozzle exit area **40** to adjust fan bypass airflow such that the angle of attack or incidence on the fan blade is maintained close to design incidence at other flight condi-